ELEC 462/562: Optoelectronic Devices

Junichiro Kono

Fall 2020

Time and Place

Time: 11:20 am – 12:40 pm CT, Tuesdays & Thursdays
Place: M. D. Anderson Biological Laboratories, Room 130

Contact Information

Instructor: Junichiro Kono
Office: 351 Brockman Hall
Email: kono@rice.edu
Office Hours: 12:00–2:00 pm CT, Wednesdays (via Zoom)

Technology TA: Ted Grosson
Email: tag10@rice.edu

Course Objectives and Learning Outcomes

This course provides an introduction to the fundamental principles of semiconductor optoelectronic devices. After reviewing the basic elements of quantum mechanics of electrons and photons, light-matter interaction (including laser oscillations), and semiconductor physics (band structure, heterostructures and alloys, optical processes), we will study the details of modern semiconductor devices for generating, detecting, and modulating light.

Texts and Materials

J. Kono, *Quantum Mechanics for Tomorrow's Engineers* (Cambridge University Press)

This book will be published in January 2021. You will be able to download a pdf copy of the latest version through Canvas. Your proofreading and feedback will be reflected in the final version and acknowledged. In addition, the following texts are recommended:

- E. Rosencher & B. Vinter, *Optoelectronics* (Cambridge University Press)
- S. L. Chuang, *Physics of Photonic Devices* (Wiley)
- S. O. Kasap, *Optoelectronics and Photonics: Principles and Practices* (Pearson)
- A. Yariv, *Quantum Electronics* (Wiley)
- A. E. Siegman, *Lasers* (University Science Books)
- R. W. Boyd, *Nonlinear Optics* (Academic Press)
- C. Weisbuch & B. Vinter, *Quantum Semiconductor Structures: Fundamentals and Applications* (Academic Press)
- J. H. Davies, *The Physics of Low-Dimensional Semiconductors: Introduction* (Cambridge)
- J. Singh, *Physics of Semiconductors and Their Heterostructures* (McGraw Hill)
- G. Bastard, *Wave Mechanics Applied to Semiconductor Heterostructures* (Wiley)

Homework

A problem set will be assigned every other week. Late homework assignments will be accepted with a penalty of 10% per class period after they are due.

Exams

There will be two exams: the Midterm Exam and the Final Exam. Both exams will be take-home, open-book exams.

Grading

Homework 40%; Midterm Exam 30%; Final Exam 30%.

Attendance

- All students who live four or fewer time zones away are expected to attend every class synchronously, either in person or via Zoom.
- All students who are living where the time zone is >4 hours from the Central Time Zone are expected to either attend class synchronously via Zoom or to work out in advance with the instructor a suitable solution for asynchronous attendance.
- When you need to change your typical mode of attending class during the semester (e.g., switching between in-person and remote participation), you should inform the instructor of the change.

Participation

Students are expected to be actively engaged in the classroom. If you are joining class remotely, please keep your video camera on and microphone muted. Use the Chat, Raise Hand, Unmute, etc. features in Zoom when you have questions or would like to participate. Students needing an accommodation for using their camera or microphone should contact the instructor at the beginning of the semester to discuss and work out needed adjustments.

Office Hours

- In person office hours are by appointment only. Email the instructor to set up an appointment and/or use Google Calendar to set up an appointment.
- Remote office hours will be conducted via Zoom at 12:00–2:00 pm CT on Wednesdays. Use this Zoom link for office hours: https://riceuniversity.zoom.us/j/97942191795?pwd=QTNxQmd0UE5PdEFuZmdMNjU2SlVndz09 (Meeting ID: 979 4219 1795, Passcode: 305682). Please be patient if the instructor is meeting with another student.
  - When you arrive for remote office hours, you may be directed to the waiting room.
  - When you arrive for remote office hours, you will be able to immediately join the meeting. Type your name in the Chat window and briefly state the topic or question you would like to discuss (e.g., problem 5 in the homework; personal matter). This may enable the instructor to organize small groups of students who want to discuss the same question/topic.

PPE & Physical Distancing

- Every student in the classroom is expected to properly wear a mask or face covering and to abide by Rice's physical distancing policy (maintain at least six feet of distance from other persons whenever possible).
- The instructor reserves the right to instruct students to leave the classroom if they are engaging in behavior that places faculty and/or students' health at risk. If students do not comply, the instructor may cancel the class meeting and refer the student to Student Judicial Programs and the Dean of Undergraduates or the Dean of Graduate and Postdoctoral Studies.
- Please leave the classroom immediately after class ends. This will help reduce the crowding that occurs between class periods.
- If you have questions at the end of class, please submit them via email or attend office hours. If you email a question, the instructor will try to answer it within 24 hours during weekdays.

Technology Resources

- Students attending remotely must have a working computer with a video camera, speaker and a microphone, and a working internet connection that allows them to be on video. Students should test their equipment before joining class. Undergraduate students should contact the Dean of Undergraduates if they have concerns about meeting this requirement. Graduate students should contact their department.
- If your computer/phone has no webcam/microphone, please let the instructor know as soon as possible and contact the Dean of Undergraduates if you need to request support via the Access and Opportunity Portal (HTTPS://AOP.RICE.EDU/APPLICATION), contact your academic department if you are a graduate student, request to borrow one from the Digital Media Commons.

Privacy and Confidentiality

In line with FERPA requirements, recorded classroom discussions involving students will be available only to students officially registered and enrolled in the class. If you have concerns about appearing on these recordings, please contact the instructor ahead of time.

Rice Honor Code

In this course, all students will be held to the standards of the Rice Honor Code, a code that you pledged to honor when you matriculated at this institution. If you are unfamiliar with the details of this code and how it is administered, you should consult the Honor System Handbook at http://honor.rice.edu/honor-system-handbook/. This handbook outlines the University's expectations for the integrity of your academic work, the procedures for resolving alleged violations of those expectations, and the rights and responsibilities of students and faculty members throughout the process.

Disability Resource Center

If you have a documented disability or other condition that may affect academic performance you should: 1) make sure this documentation is on file with the Disability Resource Center (Allen Center, Room 111 / adarice@rice.edu / x5841) to determine the accommodations you need; and 2) talk with me to discuss your accommodation needs.

Syllabus Change Policy

This syllabus is only a guide for the course and is subject to change with advanced notice.

Course Schedule

1. **Basic Elements of Quantum Mechanics and Light-Matter Interaction**
   (a) Time-independent Schrdinger equation
   (b) Perturbation theory and transition probabilities
   (c) Linear optical susceptibility
   (d) Absorption, stimulated emission, and spontaneous emission
   (e) Laser oscillations
2. **Basics of Semiconductor Physics**
   (a) Band structure
   (b) Electronic and optical properties of semiconductors
   (c) Semiconductor heterostructures and quantum wells
3. **Optoelectronic Devices**
   (a) Waveguides
   (b) Photodetectors and solar cells
   (c) Light emitting diodes
   (d) Laser diodes